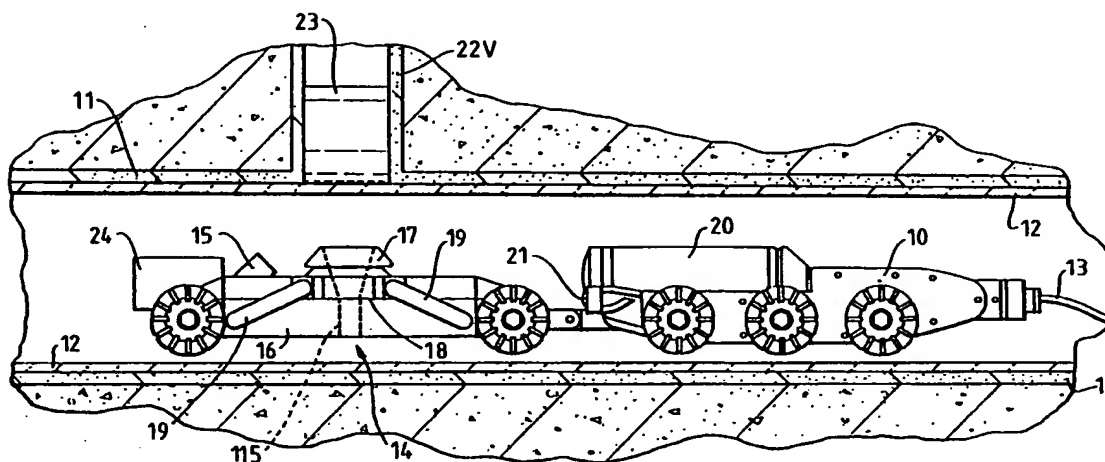




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(54) Title: APPARATUS FOR USE IN THE REPAIR AND MAINTENANCE OF CONDUITS SUCH AS SEWERS



(57) Abstract

The apparatus described comprises a wheeled vehicle (14) to be driven through a conduit (11) having a newly-inserted lining (12), by an electric tractor (10) which is powered through a cable (13). The vehicle (14) carries a pyro solid-state thermal imaging device (15) which scans the lining interior to locate laterals (22) by detecting temperature differences at lining areas which are not backed or backed only by water. The vehicle also carries a cutter having a motor-driven head (17) which can be actuated to cut an orifice in the lining (12) and so open the conduit to the lateral (22V, 22H). The vehicle (14) also carries a miniature T.V. camera (20) to inspect the lining and also cutting operations. Signals from the thermal-imaging device (15) and from the camera (20) are transmitted through the cable (13) to a T.V. monitor (not shown) at a remote location where an operator controls the movement of the tractor (10) and the operation of the cutter head (17). The apparatus can also be used to detect voids behind an unlined conduit.

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APPARATUS FOR USE IN THE REPAIR AND MAINTENANCE
OF CONDUITS SUCH AS SEWERS

5 This invention relates to the repair and maintenance of relatively inaccessible conduits such as sewers, and is particularly intended for use in locating laterals in a lined conduit.

10 In the repair and maintenance of sewers and other conduits, it is well known to insert a lining to resist leakage and further deterioration. Lining or relining may be effected by, for example, inverting a resin-impregnated sock into the conduit and curing the resin by heating with water to form a substantially rigid reinforced pipe within a pipe. Another method is to pull in sections of butt-welded plastics pipe similar to the pipe used in the gas industry.

15 A major problem with underground and other conduits which are more or less inaccessible, is the location of so-called 'laterals' - in sewers, house connections - which must be opened to the main conduit. Known methods include dead-reckoning which is not usually very accurate, and excavation which can be
20 extremely inconvenient. It has also been proposed to emplace mild radio-active sources or small radio transmitters in the laterals but, apart from the expense involved, it is necessary to recover these items after completion of the operation.

25 It is an object of the present invention to provide an apparatus for locating laterals in a lined conduit, the apparatus preferably also having means for forming openings in the lining to connect with the laterals.

It is another object of the invention to locate voids or unbacked areas in an unlined conduit.

30 According to the present invention, there is provided an apparatus for use in locating laterals in a lined conduit or

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unbacked areas in an unlined conduit, comprising: a vehicle to be passed through the conduit, a sensitive thermal imaging device so carried by the vehicle as to view the conduit lining or the unlined conduit, and a remote TV monitor which receives signals from said device to display the thermal images of the inside face of the lining or the unlined conduit, said images identifying the positions of any laterals or unbacked areas due to the temperature differential between fully-backed and relatively-unbacked areas of the lining or the unlined conduit.

Preferably, said sensitive thermal - imaging device is a pyro solid-state device comprising an uncooled 100 x 100 thin-film absorber monolithic pyro electric array mounted on a movable support on the vehicle, the support being arranged to rotate and/or swivel so that at least the upper and side surfaces of the lining or the unlined conduit can be viewed.

Preferably also, the vehicle comprises a tractor which additionally carries a miniature scanning TV camera and an illuminator.

In another application of the apparatus according to the invention, the vehicle is passed through an unlined pipe to locate any voids or unbacked areas - for example, areas where the earth or a casing around a sewer had been eroded or otherwise removed or damaged.

When used in lined conduits, the apparatus preferably also includes a cutter to form openings in the lining to communicate with the located laterals and means may be provided for accurately targeting the cutter by the aforementioned thermal sensor.

Embodiments of the present invention will now be described, by way of example, with reference to the accompanying drawings in which:

Figure 1 is an elevational view showing an apparatus

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5 according to the invention, located within a lined pipe which has an upwardly-extending lateral;

Figure 2 is an end view corresponding to Fig. 1;

Figure 3 is a plan view showing the vehicle within a lined pipe which has a horizontally-extending lateral;

10 Figure 4 is an end view corresponding to Fig. 3, but showing a lining cutter in an intermediate position; and

Figure 5 is a plan view similar to Fig. 3 but showing the cutter in its operational position.

15 Referring to Figs. 1 and 2 of the drawings, the apparatus comprises an electric tractor or crawler 10 which is driven through a conduit 11 having a newly-inserted lining 12. The tractor is powered through a cable 13 which extends to a remote TV monitor and control unit (not shown) such as marketed under the Trade Marks PEARPOINT and MIMIC and described in U.K. Patent No. 2215942. The tractor drives a wheeled vehicle 14 which
20 carries a pyro solid-state device 15 comprising a thermal imager and camera, suitably a 100 x 100 thin-film absorber monolithic pyro electric array such as described by M.M. Shorrocks et al in a paper entitled "Uncooled IR Thermal Detector Arrays" published in the proceedings of the S P I E, Vol. 1320, pp 88-94, 1990,
25 and presented at a conference on IR Technology Applications held 26/28 June 1990 in Wembley, London. This device has a relatively low resolution but does not require cooling as do the comparable platinum-silicide or mercury-telluride devices used in normal thermal imaging.

30 The device 15 is mounted on a body part 16 which can rotate on a horizontal axis through approximately 180°, the mid position being shown in Figs. 1, 2, and 3. The body part 16 also carries a lining cutter device comprising a rotary cutter head 17 driven by motor 18 and mounted on two pairs of links 19 which pivot to
35 advance and retract the head 17 transversely.

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A miniature scanning TV camera 20 such as described in U.K. Patent No. 2210530 or No. 2215941 and marketed under the Trade Mark PEARPOINT, is mounted on the tractor 10, together with illuminator lamps 21.

5 In use, the apparatus is introduced into the lined conduit, as soon as is practical after the lining 11 has been inserted, and is driven relatively slowly along the length of the conduit while the body part 16 swivels more or less continuously. The
10 body part swivels, back and forth through an angle of about 180°, so that the device 15 sweeps at least the upper half of the lining interior which is thus imaged on the TV monitor. When the apparatus reaches a lateral such as 22V in Figs. 1 and 2, or 22H in Figures 3 to 5, the monitor screen reflects the
15 difference in temperature between the interior surface of the lining which is backed by the body of the conduit 10, and the surface at the lateral where there is no backing or only a water backing. This difference may be very small, but the pyro solid-state device 15 is very sensitive and can detect a temperature
20 difference of as little as 0.1C°. The (remote) operator stops the forward movement of the tractor and then aligns the cutter head 17 with the centre of the lateral 22V/22H, both longitudinally and also correctly orientated in the vertical plane, by swivelling the body part 156 as shown in Fig.4. Next,
25 cutter head 17 is moved into contact with the liner 11 and rotated to cut a circular orifice and so open the conduit to the lateral as shown in Fig. 5; the apparatus is sufficiently robust and waterproof to resist damage by any residual liquid 23 or rubble in the lateral, and is then moved on to open the next lateral. The device 15 itself may also, or alternatively, be
30 arranged to rotate or swivel to sweep the lining interior and/or to give a forward view of the conduit.

The positioning and operation of the cutter is assisted and monitored by the illuminated TV camera 20 and it will be appreciated that, although the images from the 100 x 100 pixels
35 device 15 may be sufficient to locate the lateral, the "picture" may not have sufficient resolution for checking satisfactorily

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on the completion of the cutting operation. To improve the accuracy of location of the cutter 17 before an orifice-forming operation, a "cross-hair" target is imaged on the monitor screen and the target is centred on the bore of the lateral by a micro-processor which receives an input by detecting the circular grey-scale ring which shows the presence of the circular wall of a lateral.

The general illustration of the lining surface may be further clarified, and the operation of the apparatus facilitated, by providing a forward-viewing thermal imager and camera unit 24 to present advance warning of approaching laterals, and also of unexpected obstacles.

In a modified version of the apparatus, the pyro solid-state device (15) is mounted at the base of the body part, as shown in broken lines at 115 in Figures 1 and 5, to scan the lining through a central opening formed in the motor 18 and the cutter 17.

In a further modified form, the vehicle is pulled through the conduit by a suitable cable, or is pushed through by means of a semi-rigid rod such as described in U.K. Patent No. 2172079 and marketed under the Trade Mark FLEXIPROBE.

Other modifications may be made without departing from the scope of the invention and, as mentioned above, the apparatus can be used to detect voids behind an unlined conduit; such voids would appear as grey areas on the monitor screen, and would be logged or treated by injection or through subsequent excavation. In this case the cutter would not be required, unless for "refacing" junctions between the conduit and any laterals which might open to the conduit.

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Claims:

1. An apparatus for use in locating laterals in a lined conduit or unbacked areas in an unlined conduit, comprising: a vehicle to be passed through the conduit, a sensitive thermal imaging device so carried by the vehicle as to view the conduit lining or the unlined conduit, and a remote TV monitor which receives signals from said device to display the thermal images of the inside face of the lining or the unlined conduit, said images identifying the positions of any laterals or unbacked areas due to the temperature differential between fully-backed and relatively-unbacked areas of the lining or unlined conduit.
2. An apparatus as claimed in Claim 1, in which said sensitive thermal - imaging device comprises a pyro solid-state device.
3. An apparatus as claimed in Claim 2, in which said pyro solid-state device comprises a 100 x 100 thin-film absorber monolithic pyro electric array.
4. An apparatus as claimed in Claim 2 or Claim 3, in which said pyro solid-state device is mounted on a movable support on said vehicle, said support being arranged to rotate and/or swivel so that at least the upper and side surfaces of the lining or the unlined conduit can be viewed.
5. An apparatus according to any preceding Claim, in which a scanning T.V. camera and an illuminator are also carried on said vehicle.
6. An apparatus as claimed in any preceding Claims, in which a forward-viewing thermal imager and T.V. camera unit

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are also mounted on said vehicle, to give advance warning of approaching laterals or unbacked areas, and also unexpected obstacles.

5 7. An apparatus as claimed in any preceding Claim, in which said vehicle comprises an electric tractor.

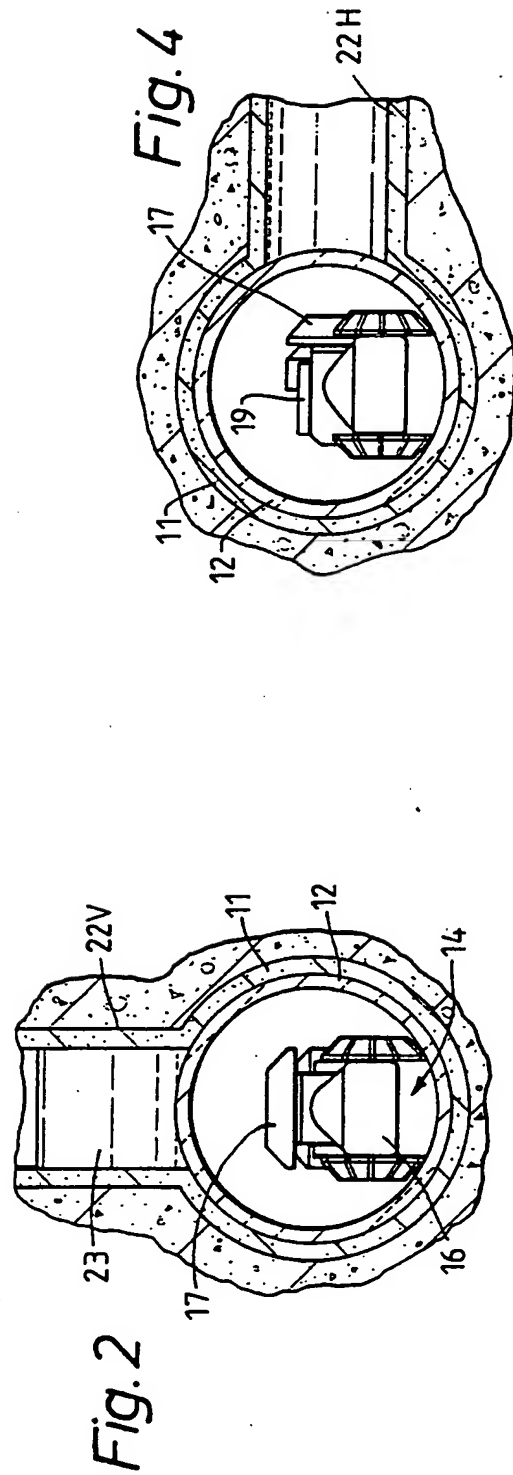
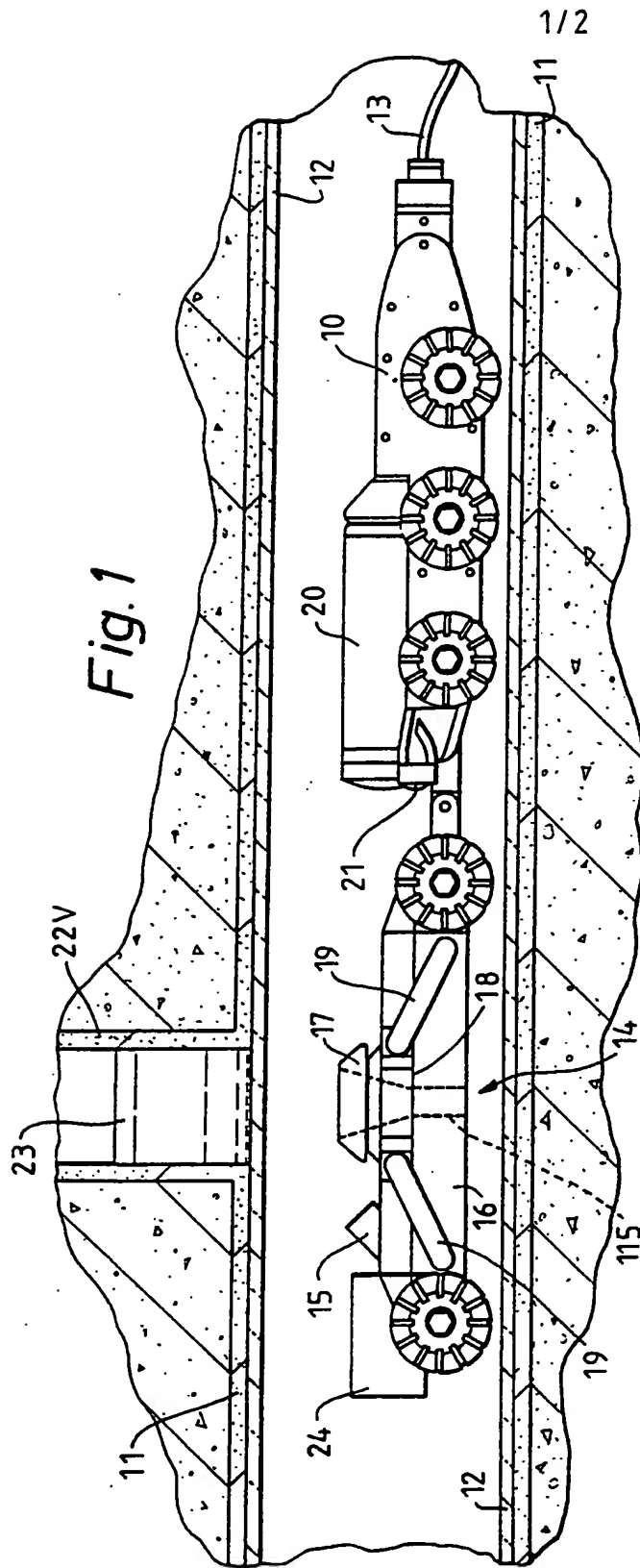
10 8. An apparatus as claimed in any preceding Claim, for use with lined conduits, and also including a cutter to form openings in the lining to communicate with the located laterals.

15 9. An apparatus as claimed in Claim 8, in which means are provided for accurately targeting the cutter, said means comprising a microprocessor which detects the circular outline of a lateral and presents a target at the centre of the outline.

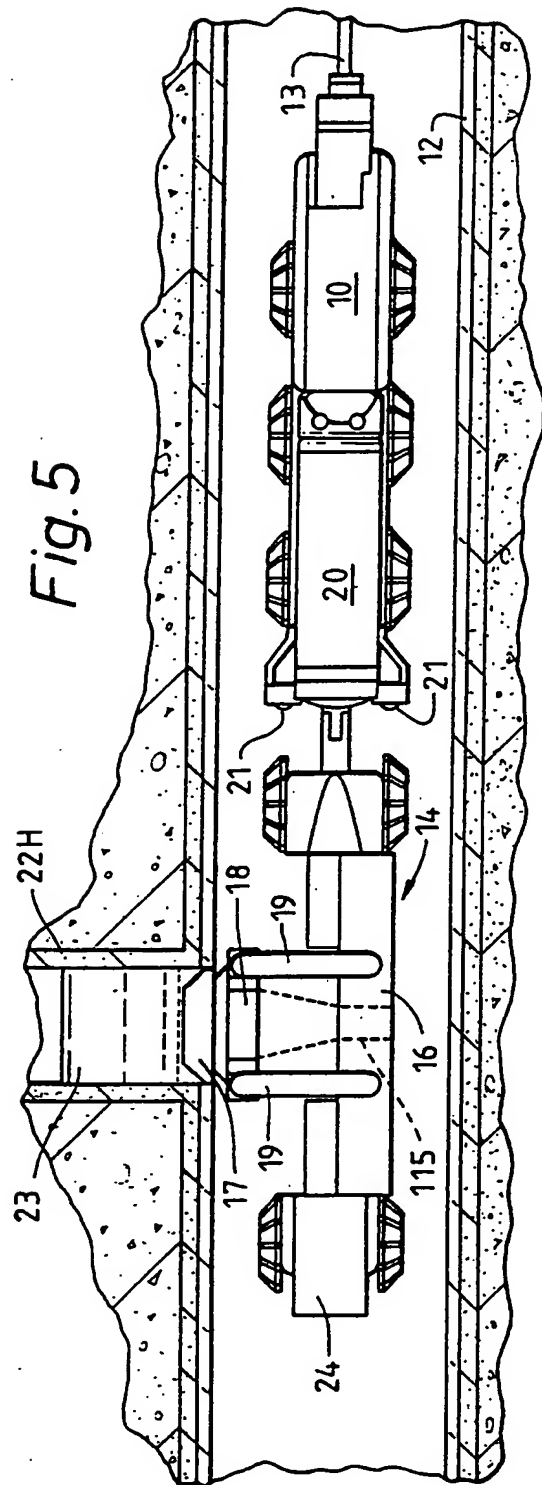
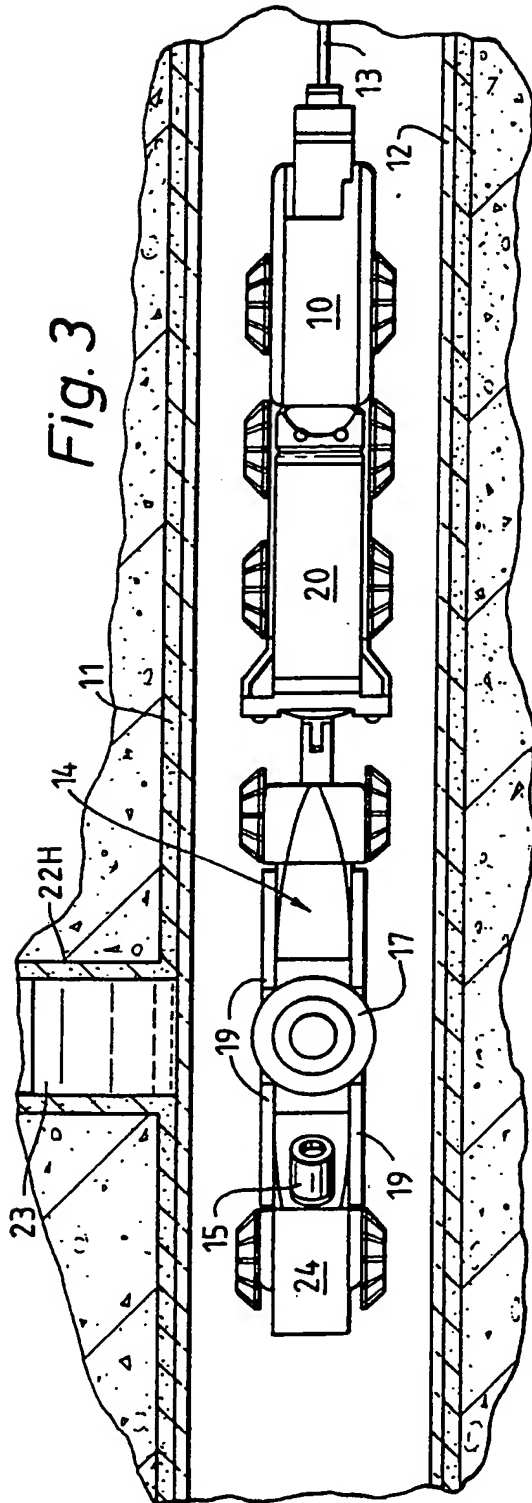
20 10. An apparatus as claimed in any preceding Claim, and further comprising a control unit at the remote location of said T.V. monitor where an operator can inspect and control the operation of the apparatus.

25 11. An apparatus for use in locating laterals in a lined conduit, substantially as hereinbefore described with reference to the accompanying drawings.

12. The features herein described, or their equivalents, in any patentably novel selection.



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INTERNATIONAL SEARCH REPORT

International Application No
PCT/GB 93/02201

A. CLASSIFICATION OF SUBJECT MATTER
IPC 5 F16L55/16 F16L55/18

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC 5 F16L G01J

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	DE,U,90 11 439 (OTTO SCHLEMMER GMBH) 18 October 1990 see page 3, line 6 - page 4, line 11; figures see page 10, line 29 - page 12, line 29 see claims 7,13	1,8, 10-12
Y	---	2,3
A	---	4,5
Y	LETTINGTON 'INFRARED TECHNOLOGY AND APPLICATIONS' 26 June 1990, SPIE-THE INTERNATIONAL SOCIETY FOR OPTICAL ENGINEERING, BELLINGHAM, WASHINGTON, USA cited in the application UNCOOLED INFRARED THERMAL DETECTOR ARRAYS see page 88 - page 94 ---	2,3
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☒ Further documents are listed in the continuation of box C.

☒ Patent family members are listed in annex.

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Date of the actual completion of the international search

15 February 1994

Date of mailing of the international search report

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C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	WO,A,91 11283 (TRB) 8 August 1991 see abstract; figures see page 2, line 24 - page 3, line 27 ---	1,8, 10-12
A	GB,A,2 157 796 (RICE) 30 October 1985 see abstract; figures -----	1,8-12

INTERNATIONAL SEARCH REPORT

Information on patent family members

Inter nal Application No

PCT/GB 93/02201

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
DE-U-9011439	18-10-90	NONE	
WO-A-9111283	08-08-91	US-A- 5105882	21-04-92
		AU-A- 7224291	21-08-91
		US-A- 5088553	18-02-92
GB-A-2157796	30-10-85	NONE	